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INVENTOR-INFORMATION:

NAME	COUNTRY
SMYTH, CHARLES NORMAN	N/A

ASSIGNEE-INFORMATION:

NAME	COUNTRY
SMYTH CHARLES NORMAN	N/A

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ABSTRACT:

Electronic apparatus with search coils or capacitance electrodes for detecting the presence of electrically conducting, magnetic or dielectric materials is formed integral with or constructed to be mounted upon **footwear**.

Search coils, are on each foot, are fed from an oscillator 1 via a pair of transformers 2, 3. Secondary coils on the transformers are connected in opposition and via an amplifier 4 to detector 10 which is also supplied from the oscillator. Any change in the induction of one of the several coils unbalances the secondary windings which supply an output signal to the detector. The oscillator supply to

detector may be controlled by a ground proximity detector, including oscillator 13, sensitive to foot height above ground level.

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(71) Applicant
Charles Norman Smyth,
6 Elmsworthy Terrace,
London NW3 3DR
(72) Inventor
Charles Norman Smyth
(74) Agent and/or Address for Service
C. N. Smyth,
6 Elsworthy Terrace,
London NW3 3DR

(54) **Detector combined in footwear**

(57) Electronic apparatus with search coils or capacitance electrodes for detecting the presence of electrically conducting, magnetic or dielectric materials is formed integral with or constructed to be mounted upon footwear.

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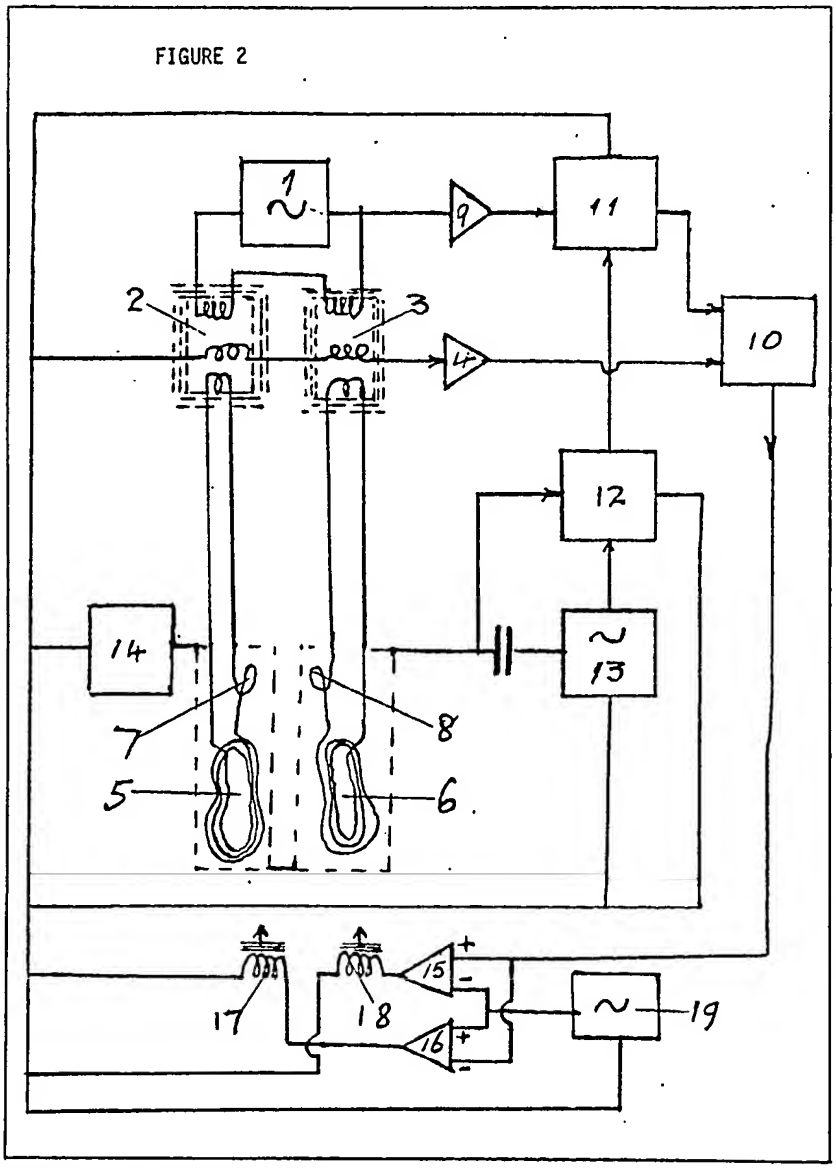
FIGURE 2



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This print takes account of replacement documents later filed to enable the application to comply with the formal requirements of the Patents Rules 1978 or 1982.

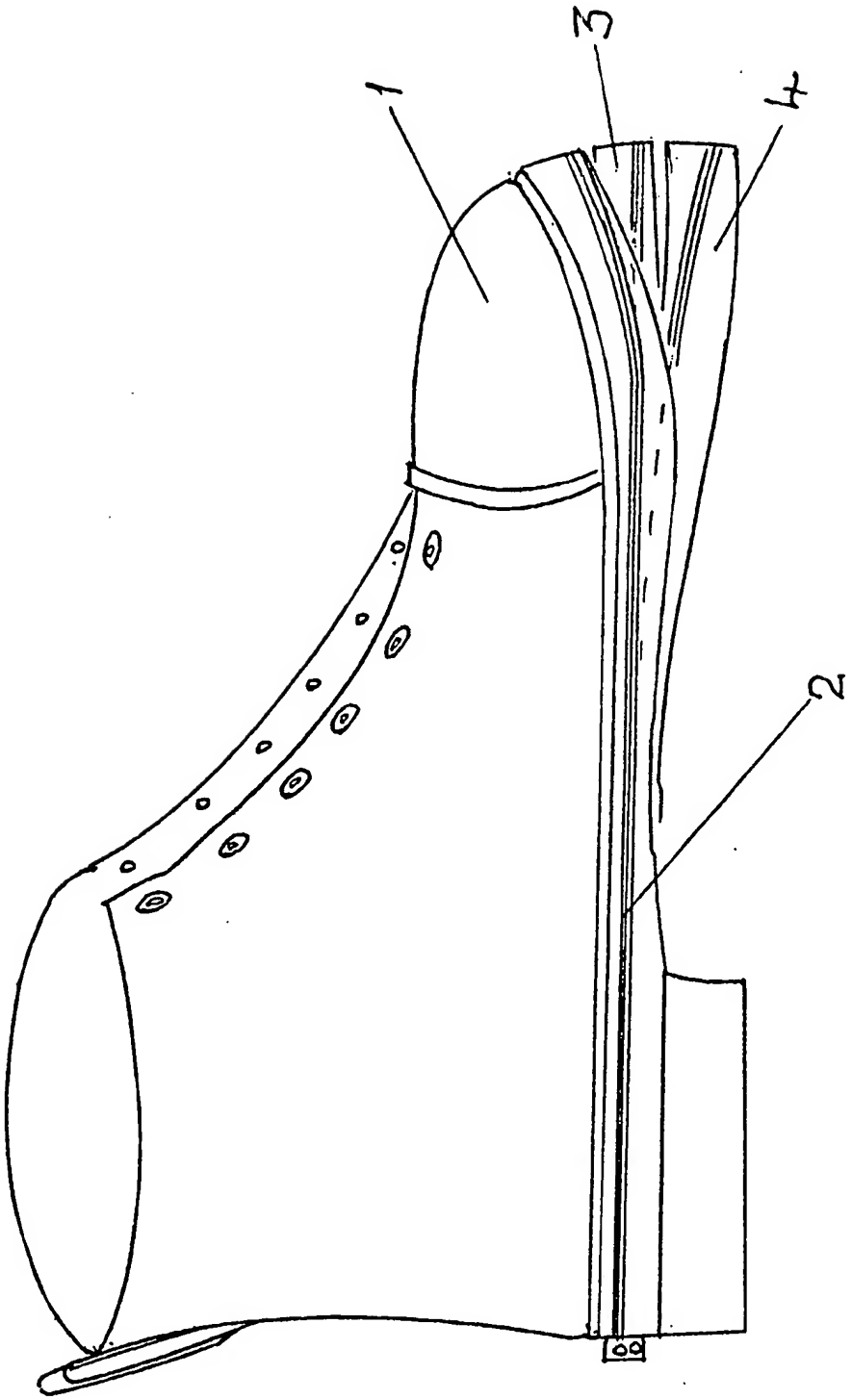
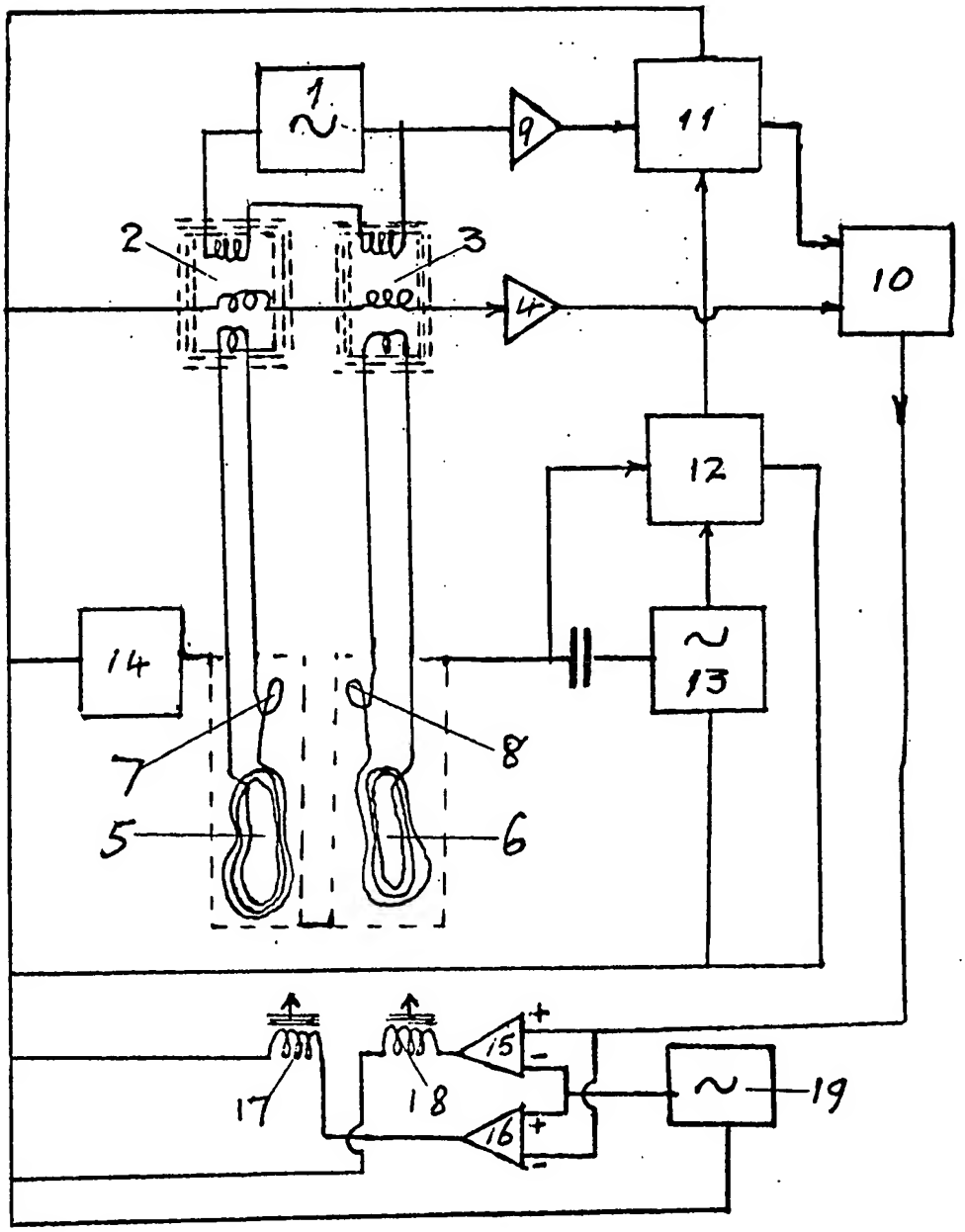


FIGURE 1

FIGURE 2



SPECIFICATION

Metal detector combined in footwear

The invention relates to electronic apparatus designed to react to electrically conducting, dielectric or magnetic materials in the environment. Such apparatus will be referred to as "metal detectors" although they also respond to ionic conductivity, to dielectric or ferro-magnetic compounds or to areas where these properties are unexpectedly absent due to a concealed artefact in the ground or shallow water-bed where the apparatus could be employed.

Metal detectors comprise a source of electrical power, transmitting and receiving inductances and or capacitance electrodes, oscillators, amplifiers and phase-sensitive electrical signal detectors and audible, visible or touch sensation or vibration sensation transducers to communicate the electrical state of the ground or water where the device is applied to the user. Metal detectors in which the transmitting-receiving elements are carried on a rod or probe are well known and have been commercially available for many years.

According to the invention the metal detector or the transmitting receiving elements of the metal detector are incorporated in footwear so that the device may be used while walking and signal to the wearer if he treads over an unusual area or give an advance signal should a foot approach certain detectable hazards. The design of an apparatus to achieve the invention requires modification to the circuitry hitherto employed in metal detectors to overcome the varying distance of the foot above the ground and to neutralise unwanted coupling between the two feet when the feet pass close to each other and on occasions to arrange for the circuit elements on each foot to combine to localise an object more exactly.

In one form of the invention the transmitting-receiving coils or electrodes are transformer coupled to the main circuit to enable a balanced ground response to be obtained when the two feet are over similar ground. Transformer coupling also enables low-impedance coils of few turns to be adequate on the footwear.

The invention envisages the receiving-transmitting coils or electrodes made integral with shoes, boots, overshoes (galoshes) or formed to be attached to footwear.

Where the miniaturised circuitry is also integral with or attached to the footwear the signal transducers may stimulate one or the other leg or foot of the user vibrationally.

In some embodiments of the invention to achieve compensation for the varying effect of the ground as the foot height above the ground varies adjustment of magnitude and phase balance may be effected by a proximity detector circuit controlled by capacitance to ground. To neutralise coupling between the foot carried coils as the legs approximate two small coils, one on each foot in a substantially vertical plane, in series with the receiving-transmitting coils, may be phased to effect.

Where the invention is applied to footwear of a flexible nature such that the sole bends as the user walks and thus changes the inductance of the coil the coils may be formed upon the footwear with a bend so arranged that the coil becomes approximately planar when the sole is half-flexed, as shown in fig (1) where

(1) is the outline of a boot with plastic sole into which a three turn search coil is embedded

(2) shown in the fully flexed position

(3) denotes the position of the sole and coil in the mid-flexed position

(4) denotes the sole and coil in the resting position.

To achieve simplicity in the construction of the footwear coils they may be reduced to a single turn or only a few turns and transformer coupled to the oscillator and input circuits. An advantage of such transformer coupling is also that the adverse effects of ionic conduction or ferromagnetic material in the ground is approximately balanced out by the differential action of the two feet.

In a simplified form of the invention the metal detector may be applied to only one foot or made operative on only one foot at a time by the use of a foot pressure operated switch.

An embodiment of the invention is now described with reference to figure (2): The circuit elements are shown schematically. (1) is an oscillator of above audible frequency approximately 20 Kilohertz. It supplies energy to two magnetic cored impedance transformers (2) and (3). Secondary windings on these transformers are connected in opposition and provide when balanced a null output to the input amplifier (4). On each of the transformers (3) and (4) is a third single turn winding joined to the two foot coils (5) and (6). Single turn coils (7) and (8) in series with coils (5) or (6) provide compensation for changes in mutual inductance between coils (5) and (6). An amplifier (9) takes an input from the oscillator (1) and its output when amplified and phase corrected together with the input signal from the amplifier (4) are applied to a phase sensitive gate (10) to provide a positive or negative direct current output when the foot coils (5) and (6) become unbalanced through unequal ground effects. Between amplifier (9) and the phase gate (10) is inteposed transistorised reactive phase-shift circuit (11) with manual adjustment and partial automatic adjustment afforded by the variable conductivity of the proximity detector (12). The proximity detector has a high-frequency oscillator (13) the output of which is governed by the capacitance of the foot-electrodes to ground. The foot coils have Faraday screens to prevent unwanted capacitance effects between the coils themselves on to the ground. These Faraday screens by their variable capacitance to ground also function to control the output of the proximity detector (12). A wave filter network (14) holds the Faraday screens at ground potential at the frequency of oscillator (1) while enabling

them to maintain a potential above ground at the high-frequency of oscillator (13). The direct current output from the phase gate (10) operates one of two gate circuits (15) and (16), one is sensitive to negative and one to positive currents and thus energise one of two vibration transducers (17) and (18) from the low frequency, 300 Hertz, oscillator (19). If the phase balance is appropriately set an increase in inductance of one foot coil over the other will operate a transducer indicative of that leg while a reduction in inductance will operate the other transducer thus distinguishing between magnetic and non-magnetic material.

CLAIMS

1. An electronic apparatus with search coils or electrodes reactive to electrically conducting, magnetic or dielectric material made integral with or constructed to be mounted upon footwear.

2. An apparatus as claim 1 in which the detector circuitry is integral with or mounted upon footwear.

3. An apparatus as claim 1 having as an output a vibration sense transducer.

4. An apparatus as claim 1 in which the foot elements are energised alternately through the action of a pressure sensitive switch or a proximity transducer.

5. An apparatus as claim 1 in which foot electrodes form part of a proximity to ground detector circuit.

6. An apparatus as claim 1 having auxillary foot mounted coils in a substantially vertical plane to react with each other.

7. An apparatus as claim 1 in which the foot coils are flexible and approximately flat in the half-bent position.

8. An apparatus as claim 1 in which the foot elements can be connected to form a single search unit.

9. An apparatus as claim 1 in which the circuit can only operate when the feet are in a predetermined position with respect to each other.

10. An apparatus as described in the accompanying diagrams and description.

New claims or amendments to claims filed on 3rd May 1983.

Superseded claims: Claim 1

New or amended claims:—

1. An electronic alternating or varying current device with search inductive coils and or capacitance electrodes reactive to conducting, magnetic or dielectric material said coils or electrodes integral with or constructed to be mounted upon footwear.

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